The Examiner asserted that Ishida et al. disclose a stamper comprising a main body having an embossing surface including a negative image of the servo pattern, wherein the embossing surface is formed of a material meeting applicants' claimed Markush limitations. The Examiner did not identify what material met the claimed Markush limitation.

Contrary to the Examiner's assertion, Ishida et al. do not anticipate the claimed stamper because Ishida et al. do not disclose an embossing surface formed of platinum, carbon, a polycarbonate, a polyetherimide, a polypropylene, or a polyethylene, as required by claim 23. If the Examiner maintains this rejection, Applicants request the Examiner identify which claimed material is disclosed by Ishida et al. and specify, with particularity, where Ishida et al. discloses an embossing surface formed of one of the claimed materials.

Claims 16, 18, 20, 21, and 23 were rejected under 35 U.S.C. § 102(b) as being anticipated by Takeoka et al. (U.S. Patent No. 4,845,000). This rejection is traversed, and reconsideration and withdrawal thereof respectfully requested.

The Examiner asserted that Takeoka et al. teach a stamper comprising a main body, formed of a first metal, having an embossing surface including a negative image of servo patterns, and means for facilitating release of the embossing surface of the stamper from a layer subsequent to embossing the servo patterns, wherein the embossing surface is formed of a material meeting applicants' claimed limitations. The Examiner did not identify what material met the claimed limitations. As regards claims 21 and 23, the Examiner alleged that element 52 of Fig. 2C corresponds to an embossing surface of a material meeting applicants' claimed limitations.

Contrary to the Examiner's assertion, Takeoka et al. do not anticipate the claimed stamper because Takeoka et al. do not disclose an embossing surface formed of platinum,

carbon, or a hydrophilic polymer, as required by claim 16; and Takeoka et al. do not disclose an embossing surface formed of platinum, carbon, a polycarbonate, a polyetherimide, a polypropylene, or a polyethylene, as required by claim 23. The Examiner erroneously concludes that element 52 of Takeoka et al. is an embossing surface. As is clearly illustrated in Fig. 2C of Takeoka et al. layer 52 is not an embossing **surface.** Layer 52 is not a surface layer. The film 52 has two layers overlying it; an adhesive layer 16 and a highly releasable layer 18 made of metal. As understood by one of ordinary skill in this art, an embossing surface is the portion of the stamper that embosses the substrate to be embossed. As is known in this art, the commonly understood definition of a surface is the outer face, outside, or exterior body of a thing; outermost or uppermost layer or area. (*Random House Webster's Unabridged Dictionary, 2d ed.,* p. 1914, 1998 (attached)). Thus an embossing surface is the outer face of the stamper that embosses.

As regards claim 16, Applicants request the Examiner identify which claimed material is disclosed by Takeoka et al. and specify, with particularity, where Takeoka et al. discloses an embossing surface formed of one of the claimed materials.

Claims 16 and 18 were rejected under 35 U.S.C. § 102(b) as being anticipated by Zager et al. (U.S. Patent No. 5,552,009). This rejection is traversed, and reconsideration and withdrawal thereof respectfully requested.

The Examiner averred that Zager et al. disclose a stamper comprising a main body comprising an opaque metal relief image layer, an embossed photohardenable film, and a fluoropolymer means for facilitating release of the embossing surface of the stamper. As regards claim 18, the Examiner further asserted that Zager et al. disclose that polycarbonate can be used as a substrate.

Zager et al., however, do not anticipate the claimed stamper. Zager et al. do not disclose a stamper comprising a main body formed of a first metal and an embossing surface formed of platinum, carbon, or a hydrophobic polymer, as required by claim 16.

Further, as regards claim 18, Zager et al. do not disclose **stamper substrates** formed of polycarbonate. Rather, Zager et al. disclose that the substrate of the optically readable medium can be formed of polycarbonate.

Contrary to the Examiner's assertion with respect to claim 16, Zager et al. do not disclose a stamper with a main body comprising a first metal and an embossing surface comprising a fluoropolymer. As disclosed in column 11, lines 14-16 and lines 25-33, Zager et al. teach an opaque metal on a glass or quartz body as one embodiment of a stamper and a photopolymerized body with a release coating as another embodiment of a stamper. The Examiner apparently combined two different embodiments to reject claim 19. However, Zager et al. does not suggest combining these two **different** embodiments.

The factual determination of lack of novelty under 35 U.S.C. § 102 requires the identical disclosure in a single reference of each element of a claimed invention, such that the identically claimed invention is placed into the possession of one having ordinary skill in the art. *Helifix Ltd. v. Blok-Lok, Ltd.*, 208 F.3d 1339, 54 USPQ2d 1299 (Fed. Cir. 2000); *Electro Medical Systems S.A. v. Cooper Life Sciences, Inc.*, 34 F.3d 1048, 32 USPQ2d 1017 (Fed. Cir. 1994). There are significant differences between the claimed stampers and the stampers disclosed by Ishida et al., Takeoka et al. and Zager et al. that would preclude the factual determination that Ishida et al., Takeoka et al. and Zager et al identically describe the claimed stamper within the meaning of 35 U.S.C. § 102. As explained above, Takeoka et al. and Zager et al. do not disclose a stamper comprising a main body formed of a first metal and an embossing surface formed of

platinum, carbon, or a hydrophobic polymer, as required by claim 16; and Ishida et al., Takeoka et al. and Zager et al. do not disclose a stamper comprising an embossing surface formed of platinum, carbon, a polycarbonate, a polyetherimide, a polypropylene, or a polyethylene, as required by claim 23. Accordingly, the rejection under 35 U.S.C. § 102 is not legally viable and should be withdrawn.

Applicants further submit that Ishida et al., Takeoka et al., and Zager et al., whether taken alone, or in combination do not suggest the claimed stamper.

Claim Rejections Under 35 U. S. C. § 103

Claims 22 and 24 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Takeoka et al. and further in view of Ishida et al. This rejection is traversed, and reconsideration and withdrawal thereof respectfully requested.

The Examiner acknowledged that Takeoka et al. fail to disclose using an embossing surface formed of a polyetherimide or a main body meeting applicants' claimed limitations. The Examiner deemed that materials disclosed in Takeoka et al. and the claimed materials are known equivalents in the field of stampers, as allegedly taught by Ishida et al. The Examiner did not disclose which of the claimed materials and the materials taught by Takeoka et al. are known equivalents. The Examiner merely concluded that the disclosed materials in Takeoka et al. for the corresponding layers are equivalents in the field of known polymeric materials capable of meeting the processing and use requirements for magnetic stampers.

Claim 20 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Zager et al. and further in view of Ishida et al. This rejection is traversed, and reconsideration and withdrawal thereof respectfully requested.

The Examiner acknowledged that Zager et al. do not disclose a first metal formed of nickel. However, the Examiner noted that Zager et al. teach that conventional stampers in the art are formed using nickel. Therefore, the Examiner concluded that it would have been obvious to use nickel as the base layer of the Zager et al. stamper.

As described above, however, Zager et al. do not suggest a stamper comprising a main body formed of a first metal and an embossing surface formed of platinum, carbon, or a hydrophobic polymer, as required by independent claim 16. Thus, dependent claim 20 is allowable for at least the same reasons as claim 16.

Claims 21, 23, and 24 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Zager et al. and further in view of Ishida et al. This rejection is traversed, and reconsideration and withdrawal thereof respectfully requested.

The Examiner acknowledged that Zager et al. fail to teach forming the photohardenable film of a material meeting applicants' claimed limitations. The Examiner apparently concluded that polyimides disclosed by Ishida et al. are equivalent to the polyetherimide required by the instant claims. The Examiner declared, "polyetherimides are simply a subset of polyimides and exhibit similar properties," without explaining what are the similar properties.

The Examiner did not provide any support for the conclusion that polyetherimides are equivalent to polyimides. Polyetherimides are structurally very different from generic polyimide resin. As known in this art, polyetherimide comprises a bisphenol group in the main chain of the polymer, not required in generic polyimides. *See Concise Encyclopedia of Polymer Science and Engineering*, pp. 327-328 (attached). Though polyetherimides may be considered a species (or subset as asserted by the Examiner) of generic polyimides, a genus (polyimide) does not render a species (polyetherimide) obvious merely because the genus encompasses the species. The fact

that a claimed species or subgenus is encompassed by a prior art genus is not sufficient by itself to establish a *prima facie* case of obviousness. *In re Baird*, 16 F.3d 380, 382, 29 USPQ2d 1550, 1552 (Fed. Cir. 1994). Furthermore, Ishida et al. do not disclose that the embossing surface is formed of polyimide. As clearly explained and illustrated in Ishida et al. (col. 23, lines 4-28, and FIG. 14c) the embossing surface is the ferromagnetic layer 143, not the supporting polyimide layer 142.

Obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either explicitly or implicitly in the references themselves or in the knowledge readily available to one of ordinary skill in the art. *In re Kotzab*, 217 F.3d 1365, 1370 55 USPQ2d 1313, 1317 (Fed. Cir. 2000); *In re Jones*, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992); *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988). The Examiner has not shown any suggestion in Ishida et al., Takeoka et al., or Zager et al. to provide the claimed stamper comprising a main body formed of a first metal and an embossing surface formed of platinum, carbon, or a hydrophobic polymer, as required by claim 16; or a stamper comprising an embossing surface formed of platinum, carbon, a polycarbonate, a polyetherimide, a polypropylene, or a polyethylene. Further, the Examiner has not shown any suggestion in Ishida et al., Takeoka et al., or Zager et al. to combine the references as asserted. Although, a reference can be modified, the prior art must suggest the desirability of modifying a reference. See *In re Mills*, 916 F.2d 680, 16 USPQ2d 1430 (Fed. Cir. 1990). The Examiner has not shown any suggestion in either Ishida et al., Takeoka et al., or Zager et al. to modify the references.

The Examiner is required to discharge the initial burden by, *inter alia*, making **clear and particular** factual findings as to a **specific understanding** or **specific technological principle**

which would have **realistically** impelled one having ordinary skill in the art to modify the claims an applied reference to arrive at the claimed invention based upon facts, -- not generalizations. *Ruiz v. A.B. Chance Co.*, 234 F.3d 654, 57 USPQ2d 1161 (Fed. Cir. 2000); *Ecolochem Inc. v. Southern California Edison, Co.*, 227 F.3d 1361, 56 USPQ2d 1065 (Fed. Cir. 2000); *In re Kotzab, supra*; *In re Dembiczak*, 175 F.3d 994, 50 USPQ2d 1614 (Fed. Cir. 1999). That burden has not been discharged, as the Examiner has provided no factual basis for modifying the stampers of Ishida et al., Takeoka et al., or Zager et al. to obtain the claimed stampers. The Examiner did not make the requisite "clear and particular" factual findings to support the conclusion that one having ordinary skill in the art would have been realistically led to deviate from the teachings of Ishida et al., Takeoka et al., or Zager et al obtain the claimed stampers. Rather the Examiner merely relied on unsupported conclusory statements.

The requisite motivation to support the conclusion of obviousness must stem from the applied prior art as a whole and realistically impel one having ordinary skill in the art to modify a specific reference in a specific manner to arrive at a specifically claimed invention. *In re Deuel*, 51 F.3d 1552, 34 USPQ2d 1210 (Fed. Cir. 1995); *In re Newell*, 891 F.2d 899, 13 USPQ2d 1248 (Fed. Cir. 1989). Accordingly, the Examiner is charged with the initial burden of identifying a source in the applied prior art for the requisite realistic motivation. *Smiths Industries Medical System v. Vital Signs, Inc.,* 183 F.3d 1347, 51 USPQ2d 1415 (Fed. Cir. 1999); *In re Mayne*, 104 F.3d 1339, 41 USPQ2d 1449 (Fed. Cir. 1997). The Examiner has not met the burden of identifying a source in the applied prior art for the required realistic motivation of modifying the stampers of Ishida et al., Takeoka et al., or Zager et al. to obtain the claimed stampers comprising a main body formed of a first metal and an embossing surface formed of platinum, carbon, or a hydrophobic polymer, as required by claim 16; and comprising an embossing surface formed of

platinum, carbon, a polycarbonate, a polyetherimide, a polypropylene, or a polyethylene, as required by claim 23.

There is no factual basis in Ishida et al., Takeoka et al. and Zager et al. to support the conclusion that one having ordinary skill in the art would have been led to devise the stampers required by claims 16 and 23.

The only disclosure of the claimed stampers is found in Applicants' disclosure. The teaching or suggestion to make a claimed invention and the reasonable expectation of success, however, must both be found in the prior art, and not be based on Applicants' disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). Apparently, the Examiner has relied on impermissible hindsight reasoning in reaching the conclusion of obviousness.

The dependent claims are allowable for at least the same reasons as the independent claims and further distinguish the claimed invention. For example, claim 18 further requires that the hydrophobic polymeric material polymer comprises an amorphous thermoplastic material. Claim 20 further requires the first metal is nickel and the embossing surface is formed of a sputtered hydrophobic polymer. Claim 22 further requires that the embossing surface is formed of a polyetherimide, and claim 24 further requires that the main body is formed of a hydrophobic polymeric material.

Response to Arguments

The Examiner noted that Applicants appear to be giving the transitional phrase "formed of" a narrower definition than the Examiner deemed appropriate. Contrary to the Examiner's assumption, Applicants appreciate that claims must be given their broadest reasonable interpretation consistent with the specification during patent examination. *In re Hyatt,* 211 F.3d 1367, 1372, 54 USPQ2d 1664, 1667 (Fed. Cir. 2000). Applicants submit that the Examiner's

interpretation of the term "embossing surface" is unreasonable. The Examiner apparently considered any portion of the stamper to be included in the embossing surface. The Examiner's interpretation of embossing surface is clearly outside the plain meaning of the term "embossing surface." The words of a claim must be given their plain meaning unless applicant has provided a clear definition in the specification. *In re Zletz*, 893 F.2d 319, 321, 13 USPQ2d 1320, 1322 (Fed. Cir. 1989). "Embossing surface" as used in the instant specification and claims is, as its plain meaning suggests, the surface of the stamper that embosses. Thus, the materials that the Examiner apparently identified in the base/substrate of the prior art stampers are clearly not part of the prior art embossing surfaces.

In view of the above remarks, Applicants submit that this application should be allowed and the case passed to issue. If there are any questions regarding this Amendment or the application in general, a telephone call to the undersigned would be appreciated to expedite the prosecution of the application.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

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su·pre·mo (sə prē′mō, sŏŏ-), *n., pl.* **-mos.** *Chiefly Brit. Informal.* **1.** the person in charge; chief. **2.** a person of supreme or complete power, authority, ability, etc.: *His victory makes him the new chess supremo.* [1935–40; < Sp or It *supremo,* both < L *suprēmus* SUPREME; E sense perh. esp. < Sp *El Supremo* as the title of Latin-American dictators, e.g., J. G. Rodríguez Francia (1766–1840), Paraguayan dictator]

su·pre·mum (sə prē′məm, sŏŏ-), *n. Math.* See **least upper bound.** Also called **sup.** [< NL *suprēmum,* n. use of neut. of L *suprēmus* SUPREME[1]]

Supt., superintendent. Also, **supt.**

supvr., supervisor.

suq (sŏŏk, shŏŏk), *n.* suk.

Su·qua·mish (sə kwom′ish, -kwô′mish), *n., pl.* **-mish·es,** (*esp. collectively*) **-mish.** a member of a Salishan-speaking North American Indian people of Washington, near Puget Sound.

sur (sûr), *prep. Law.* upon; on the basis of: *sur mortgage.* [< F < L *super* SUPER-]

Sur (sŏŏr), *n.* a town in S Lebanon, on the Mediterranean Sea: site of ancient port of Tyre.

sur-[1], a prefix meaning "over, above," "in addition," occurring mainly in loanwords from French and partial calques of French words: *surcharge; surname; surrender; survive.* Cf. **super-.** [ME < OF < L *super-* SUPER-]

sur-[2], var. of **sub-** before *r: surrogate.*

su·ra (sŏŏr′ə), *n. Islam.* any of the 114 chapters of the Koran. Also, **surah.** [1655–65; < Ar *sūrah* lit., row, step, rung]

Su·ra·ba·ya (sŏŏr′ə bä′yə), *n.* a seaport on NE Java: second largest city in Indonesia; naval base. 1,556,255. Also, **Su′ra·ba′ja.** Dutch, **Soerabaja.**

su·rah[1] (sŏŏr′ə), *n.* a soft, twilled silk or rayon fabric. [1880–85; appar. var. of SURAT]

su·rah[2] (sŏŏr′ə), *n. Islam.* sura.

Su·ra·jah Dow·lah (sə rä′jə dou′lə), Siraj-ud-daula.

Su·ra·kar·ta (sŏŏr′ə kär′tə), *n.* a city on central Java, in central Indonesia. 414,285. Formerly, **Solo.**

su·ral (sŏŏr′əl), *adj. Anat.* of or pertaining to the calf of the leg. [1605–15; < NL *sūrālis,* equiv. to L *sūr(a)* calf of the leg + *-ālis* -AL[1]]

Su·rat (sŏŏ rat′, sŏŏr′ət), *n.* a seaport in S Gujarat, in W India: first British settlement in India 1612. 471,815.

sur·base (sûr′bās′), *n. Archit.* a molding above a base, as that immediately above a baseboard, the crowning molding of a pedestal, etc. [1670–80; SUR-[1] + BASE[1]]

sur·based (sûr′bāst′), *adj. Archit.* **1.** having a surbase. **2.** depressed; flattened. **3.** (of an arch) having a rise of less than half the span. [1755–65; SUR-[1] + (A)BASED lowered; modeled on F *surbaissé,* equiv. to *sur-* (intensive) + *baissé* lowered]

sur′based arch′. See **drop arch** (def. 2). [1755–65]

sur·cease (sûr sēs′), *v.,* **-ceased, -ceas·ing.** *n.* —*v.i.* **1.** to cease from some action; desist. **2.** to come to an end. —*v.t.* **3.** *Archaic* to cease from; leave off. —*n.* **4.** cessation; end. [1400–50; SUR-[1] + CEASE; r. late ME *sursesen* (v.) < MF *sursis* (ptp. of *surseoir*) < L *supersessus* (ptp. of *supersedēre* to forbear; see SUPERSEDE), equiv. to *super-* SUPER- + *sed(ēre)* SIT[1] + *-tus* ptp. suffix, with *dt > ss*]

sur·charge (*n.* sûr′chärj′; *v.* sûr chärj′, sûr′chärj′), *n., v.,* **-charged, -charg·ing.** —*n.* **1.** an additional charge, tax, or cost. **2.** an excessive sum or price charged. **3.** an additional or excessive load or burden. **4.** *Philately.* **a.** an overprint that alters or restates the face value or denomination of a stamp to which it has been applied. **b.** a stamp bearing such an overprint. **5.** act of surcharging. —*v.t.* **6.** to subject to an additional or extra charge, tax, cost, etc. (for payment). **7.** to overcharge for goods. **8.** to show an omission in (an account) of something that operates as a charge against the accounting party; to omit a credit toward (an account). **9.** *Philately.* to print a surcharge on (a stamp). **10.** to put an additional or excessive burden upon. [1400–50; late ME *surchargen* (v.) < OF *surcharger.* See SUR-[1], CHARGE] —**sur·charg′er,** *n.*

sur·cin·gle (sûr′sing′gəl), *n.* **1.** a belt or girth that passes around the belly of a horse and over the blanket, pack, saddle, etc., and is buckled on the horse's back. **2.** a beltlike fastening for a garment, esp. a cassock. [1350–1400; ME *surcengle* < MF, equiv. to *sur-* SUR-[1] + *cengle* belt < L *cingulum;* see CINGULUM]

sur·coat (sûr′kōt′), *n.* **1.** a garment worn over medieval armor, often embroidered with heraldic arms. **2.** an outer coat or other outer garment. [1300–50; ME *surcote* < MF. See SUR-[1], COAT]

CONCISE ETYMOLOGY KEY: <, descended or borrowed from; >, whence; b., blend of, blended; c., cognate with; cf., compare; deriv., derivative; equiv., equivalent; imit., imitative; obl., oblique; r., replacing; s., stem; sp., spelling, spelled; resp., respelling, respelled; trans., translation; ?, origin unknown; *, unattested; ‡, probably earlier than. See the full key inside the front cover.

sur·cu·lose (sûr′kyə lōs′), *adj. Bot.* producing suckers. [1835–45; < L *surculōsus* twiggy, equiv. to *surcul(us)* shoot, twig + *-ōsus* -OSE[1]]

surd (sûrd), *adj.* **1.** *Phonet.* voiceless (opposed to *sonant*). **2.** *Math.* (of a quantity) not capable of being expressed in rational numbers; irrational. —*n.* **3.** *Phonet.* a voiceless consonant (opposed to *sonant*). **4.** *Math.* a surd quantity. [1545–55; < L *surdus* dull-sounding, mute, deaf]

sure (shŏŏr, shûr), *adj.,* **sur·er, sur·est,** *adv.* —*adj.* **1.** free from doubt as to the reliability, character, action, etc., of something: *to be sure of one's data.* **2.** confident, as of something expected: *sure of success.* **3.** convinced, fully persuaded, or positive: *to be sure of a person's guilt.* **4.** assured or certain beyond question: *a sure victory.* **5.** worthy of confidence; reliable; stable: *a sure messenger.* **6.** unfailing; never disappointing expectations: *a sure cure.* **7.** unerring; never missing, slipping, etc.: *a sure aim.* **8.** admitting of no doubt or question: *sure proof.* **9.** destined; bound inevitably; certain: *sure death.* **10.** *Obs.* secure; safe. **11. be sure,** to take care (to be or do as specified); be certain: *Be sure to close the windows.* **12. for sure,** as a certainty; surely: *It's going to be a good day, for sure.* **13. make sure,** to be or become absolutely certain: *I'm calling to make sure that you remember to come.* **14. sure enough,** *Informal.* as might have been supposed; actually; certainly: *Sure enough, the picnic was rained out.* **15. to be sure, a.** without doubt; surely; certainly. **b.** admittedly: *She sings well, to be sure, but she can't act.* —*adv.* **16.** *Informal.* certainly; surely: *It sure is cold out. Sure, I'll come.* [1300–50; ME *sur(e)* < MF *sur,* OF *seur* < L *sēcūrus* SECURE] —**sure′ness,** *n.*

—**Syn. 1.** SURE, CERTAIN, CONFIDENT, POSITIVE indicate full belief and trust that something is true. SURE, CERTAIN, and POSITIVE are often used interchangeably. SURE, the simplest and most general, expresses mere absence of doubt. CERTAIN suggests that there are definite reasons that have freed one from doubt. CONFIDENT emphasizes the strength of the belief or the certainty of expectation felt. POSITIVE implies emphatic certainty, which may even become overconfidence or dogmatism.

—**Usage.** Both SURE and SURELY are used as intensifying adverbs with the sense "undoubtedly, certainly." In this use, SURE is generally informal and occurs mainly in speech and written representations of speech: *She sure dazzled the audience with her acceptance speech. It was sure hot enough in the auditorium.* SURELY is used in this sense in all varieties of speech and writing, even the most formal: *The court ruled that the law was surely meant to apply to both profit-making and nonprofit organizations.* See also **quick, slow.**

sure-e·nough (shŏŏr′i nuf′, shûr′-), *adj. Older Use.* real; genuine. [1535–45]

sure·fire (shŏŏr′fīr′, shûr′-), *adj.* sure to work; foolproof: *a surefire moneymaking scheme.* [1915–20; SURE + FIRE]

sure·foot·ed (shŏŏr′fŏŏt′id, shûr′-), *adj.* **1.** not likely to stumble, slip, or fall. **2.** proceeding surely; unerring: *his surefooted pursuit of success.* [1625–35; SURE + FOOT + -ED[3]] —**sure′foot′ed·ly,** *adv.* —**sure′foot′ed·ness,** *n.*

sure-hand·ed (shŏŏr′han′did, shûr′-), *adj.* **1.** using the hands with skill and confidence; dexterous. **2.** done with skill and proficiency: *a sure-handed sketch of a proposed building.* **3.** displaying the skill and experience of an expert: *a sure-handed politician.* [1945–50] —**sure′-hand′ed·ly,** *adv.* —**sure′-hand′ed·ness,** *n.*

sure·ly (shŏŏr′lē, shûr′-), *adv.* **1.** firmly; unerringly; without missing, slipping, etc. **2.** undoubtedly, assuredly, or certainly: *The results are surely encouraging.* **3.** (in emphatic utterances that are not necessarily sustained by fact) assuredly: *Surely you are mistaken.* **4.** inevitably or without fail: *Slowly but surely the end approached.* **5.** yes, indeed: *Surely, I'll go with you!* [1300–50; ME *surliche.* See SURE, -LY]

—**Usage. 2.** See **sure.**

Sû·re·té (SYR tā′), *n.* **la** (lä), the criminal investigation department of the French government.

sure′ thing′, 1. something that is or is supposed to be a certain success, as a bet or a business venture: *He thinks that real estate is a sure thing.* **2.** something assured; certainty: *It's a sure thing that he'll refuse to cooperate.* **3.** surely; for sure; O.K.; roger (often used as an interjection). [1830–40, *Amer.*]

sur·e·ty (shŏŏr′i tē, shŏŏr′tē, shûr′i tē, shûr′tē), *n., pl.* **-ties. 1.** security against loss or damage or for the fulfillment of an obligation, the payment of a debt, etc.; a pledge, guaranty, or bond. **2.** a person who has made himself or herself responsible for another, as a sponsor, godparent, or bondsman. **3.** the state or quality of being sure. **4.** certainty. **5.** something that makes sure; ground of confidence or safety. **6.** a person who is legally responsible for the debt, default, or delinquency of another. **7.** assurance, esp. self-assurance. [1300–50; ME *surte* < MF; OF *seurte* < L *sēcūritāt-,* s. of *sēcūritās* SECURITY]

sur·e·ty·ship (shŏŏr′i tē ship′, shŏŏr′tē-, shûr′i tē-, shûr′tē-), *n. Law.* the relationship between the surety, the principal debtor, and the creditor. [1525–35; SURETY + -SHIP]

surf (sûrf), *n.* **1.** the swell of the sea that breaks upon a shore or upon shoals. **2.** the mass or line of foamy water caused by the breaking of the sea upon a shore, esp. a shallow or sloping shore. —*v.i.* **3.** to ride a surfboard. **4.** to float on the crest of a wave toward shore. **5.** to swim, play, or bathe in the surf. —*v.t.* **6.** to ride a surfboard on: *We surfed every big wave in sight.* [1675–85; earlier *suff;* of uncert. orig.] —**surf′a·ble,** *adj.* —**surf′er,** *n.* —**surf′like′,** *adj.*

—**Syn. 1.** See **wave.**

sur·face (sûr′fis), *n., adj., v.,* **-faced, -fac·ing.** —*n.* **1.** the outer face, outside, or exterior boundary of a thing; outermost or uppermost layer or area. **2.** any face of a body or thing: *the six surfaces of a cube.* **3.** extent or area of outer face; superficial area. **4.** the outward appearance, esp. as distinguished from the inner nature: *to look below the surface of a matter.* **5.** *Geom.* any figure having only two dimensions; part or all of the boundary of a solid. **6.** land or sea transportation, rather than air, underground, or undersea transportation. **7.** *Aeron.* an airfoil. —*adj.* **8.** of, on, or pertaining to the surface; external. **9.** apparent rather than real; superficial: *to be guilty of surface judgments.* **10.** of, pertaining to, or via land or sea: *surface mail.* **11.** *Ling.* belonging to a late stage in the transformational derivation of a sentence; belonging to the surface structure. —*v.t.* **12.** to finish the surface of; give a particular kind of surface to; make even or smooth. **13.** to bring to the surface; cause to appear openly: *Depth charges surfaced the sub. So far we've surfaced no applicants.* —*v.i.* **14.** to rise to the surface: *The submarine surfaced after four days.* **15.** to work on or at the surface. [1605–15; < F, equiv. to *sur-* SUR-[1] + *face* FACE, appar. modeled on L *superficies* SUPERFICIES] —**sur′face·less,** *adj.* —**sur′fac·er,** *n.*

sur′face-ac·tive a′gent (sûr′fis ak′tiv), *Chem.* any substance that when dissolved in water or an aqueous solution reduces its surface tension or the interfacial tension between it and another liquid. Also called **surfactant.**

sur′face bound′ary lay′er, *Meteorol.* the thin layer of air adjacent to the earth's surface, usually considered to be less than 300 ft. (91 m) high. Also called **sur′face lay′er, atmospheric boundary layer, friction layer, ground layer.**

sur′face condens′er, a device condensing steam or vapor by passing it over a cool surface. [1860–65]

sur′face den′sity, *Physics.* quantity, as of electric charge, per unit surface area.

sur′face effect′ ship′, a large, ship-size air cushion vehicle operated over water. [1940–45]

sur′face effect′ ve′hicle. See **ACV** (def. 2).

sur′face in′tegral, *Math.* the limit, as the norm of the partition of a given surface into sections of area approaches zero, of the sum of the product of the areas times the value of a given function of three variables at some point on each section. [1870–75]

sur′face noise′, *Audio.* extraneous noise caused by physical wear or a physical flaw on a phonograph record or in a pickup system, rather than by a flaw in the equipment. [1930–35]

sur′face of light′ and shade′, (in architectural shades and shadows) a surface in a plane tangent to the parallel rays from the theoretical light source, treated as a shade surface. Also called **light and shade surface.**

sur′face of projec′tion, the surface upon which an image or a set of points is projected.

sur′face of revolu′tion, *Math.* a surface formed by revolving a plane curve about a given line. [1830–40]

sur′face plate′, *Mach.* a flat plate used by machinists for testing surfaces that are to be made perfectly flat. Also called **planometer.** [1840–50]

sur·face-print·ing (sûr′fis prin′ting), *n.* planography. [1830–40]

sur·face-rip·ened (sûr′fis rī′pənd), *adj.* (of cheese) ripened on the surface by molds or other microorganisms. [1940–45]

sur′face road′, a road or street level with its surroundings: *surface roads and elevated highways.* [1900–05, *Amer.*]

sur′face struc′ture, *Ling.* (in transformational-generative grammar) **1.** a structural representation of the final syntactic form of a sentence, as it exists after the transformational component has modified a deep structure. Cf. **deep structure. 2.** the string of words that is actually produced. [1960–65]

sur′face ten′sion, *Physics.* the elasticlike force existing in the surface of a body, esp. a liquid, tending to minimize the area of the surface, caused by asymmetries in the intermolecular forces between surface molecules. [1875–80]

sur·face-to-air (sûr′fis tŏŏ âr′), *adj.* **1.** (of a missile, message, etc.) capable of traveling from the surface of the earth to a target in the atmosphere. —*adv.* **2.** from the surface of the earth to a target in the atmosphere: *an antimissile missile fired surface-to-air.* [1945–50]

sur·face-to-sur·face (sûr′fis tə sûr′fis), *adj.* **1.** (of a missile, message, etc.) capable of traveling from a base on the surface of the earth to a target also on the surface. —*adv.* **2.** from a base on the surface of the earth to a target on the surface.

sur·face-to-un·der·wa·ter (sûr′fis tŏŏ un′dər wô′tər, -wot′ər), *adj.* **1.** (of a missile, message, etc.) traveling from the surface of the earth to a target underwater. —*adv.* **2.** from the surface of the earth to a target underwater.

sur′face wave′, *Geol.* a seismic wave that travels along or parallel to the earth's surface (distinguished from *body wave*).

sur′face yeast′. See **top yeast.**

sur·fac·ing (sûr′fə sing), *n.* **1.** the action or process of giving a finished surface to something. **2.** the material with which something is surfaced. **3.** the act or an instance of rising to the surface of a body of water. [1855–60; SURFACE + -ING[1]]

sur·fac·tant (sər fak′tənt), *n. Chem.* See **surface-active agent.** [1945–50; shortening of *surf(ace)-act(ive) a(ge)nt*]

surf′ and turf′, a steak served with seafood or fish, esp. filet mignon and lobster. Also, **surf-'n'-turf.**

surf·bird (sûrf′bûrd′), *n.* a sandpiperlike shorebird, *Aphriza virgata,* of the Pacific coast, breeding in Alaska and wintering in South America. [1830–40, *Amer.;* SURF + BIRD]

surf·board (sûrf′bôrd′, -bōrd′), *n.* **1.** a long, narrow board on which a person stands or lies prone in surfboarding. See illus. on next page. —*v.i.* **2.** to ride a surfboard. [1820–30; SURF + BOARD]

CONCISE ENCYCLOPEDIA OF POLYMER SCIENCE AND ENGINEERING

Jacqueline I. Kroschwitz, *Executive Editor*

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ENGINEERING FIBERS. See Fibers, engineering.

ENGINEERING PLASTICS

Engineering plastics are thermoplastics that maintain dimensional stability and most mechanical properties above 100°C and below 0°C. This definition encompasses plastics that can be formed into functional parts that can bear loads and withstand abuse in temperature environments commonly experienced by the traditional engineering materials: wood, metals, glass, and ceramics. Generic resins falling within the scope of this definition include acetals, polyamides (nylons), polyimides, polyetherimides, polyesters, polycarbonates, polyethers, polysulfide polymers, polysulfones, blends or alloys of the foregoing resins, and some examples from other resin types (see also Polyetheretherketones). Thermoplastic elastomers and commodity resins, such as most styrenics, acrylics, polyolefins, polyurethanes, poly(vinyl chloride)s, and related chlorinated polyolefins, lose mechanical properties below 100°C (see also Elastomers, thermoplastic). Exceptions include certain acrylonitrile–butadiene–styrene (ABS) polymers that maintain engineering properties in the vicinity of 100°C.

Plastics may be crystalline or amorphous. Acetals, most nylons, some polyesters, poly(arylene sulfide)s, and polyetherketones are crystalline resins. In general, crystalline polymers do not transmit light, whereas amorphous polymers generally do. The mode of processing or treatment can alter apparent morphology. For example, crystalline poly(ethylene terephthalate) can be made into clear film by dimensional orientation. Another property that distinguishes amorphous polymers from crystalline polymers is organic solvent resistance. In applications where solvent resistance is important, such as in gear boxes exposed to oils and greases, a crystalline polymer is the likely choice. On the other hand, for filter bowls, glazing, etc, where clarity is required, an amorphous polymer might be preferred. When treatment of polymers results in morphological change, properties can change as well. Table 1 notes general comparative properties.

Processing

Processing methods for engineering plastics include injection molding, blow molding, extrusion, reaction-injection molding, reactive casting, hot-stamping, and many others. Conceptually, any processing method appropriate to thermoplastic resins can be applied to engineering plastics. In practice, the very properties of engineering plastics such as high heat-distortion temperature (HDT) and stiff melt flow require equipment designed to cope with these more rigorous requirements.

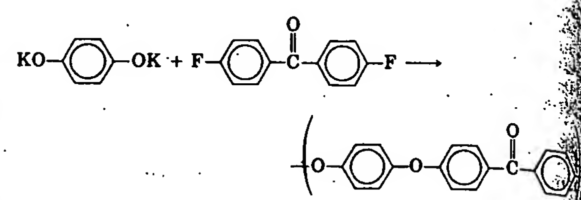
Table 1. Morphology Effects on Properties

Property	Crystalline	Amorphous
organic solvent resistance	high	low
light transmission T	none to low	high
lubricity	high	low
dimensional stability	high[a]	moderate
mold shrinkage	high	low

[a] With a high degree of crystallinity and no water absorption.

Resins

Polyetheretherketone Resin (PEEK). Polyetheretherketone resins are now produced in both the UK and the United States under the trade name Victrex PEEK resin via the displacement reaction of 4,4-difluorodiphenyl ketone by the potassium salt of hydroquinone:

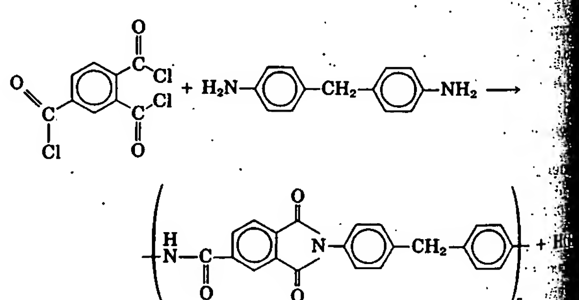


The PEEK resin is gray, crystalline, and has outstanding solvent resistance; its T_g is ca 185°C, and it melts at 288°C.

The unfilled resin has an HDT of 165°C, which can be increased to near its melting point by incorporating glass fill. The resin is thermally stable, and maintains ductility for over one week after being heated to 320°C; it can be kept for years at 200°C. Its hydrolytic stability is excellent. The resin is flame retardant, has low smoke emission, and can be processed at 340–400°C. Recycled material can be safely processed.

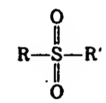
The PEEK resin is marketed as neat or filled pellets for injection molding, as powder for coatings, or as preimpregnated fiber sheet and tapes. Applications include parts that can be exposed to high temperature, radiation, or aggressive chemical environments. Aerospace and military uses are prominent.

Polyamideimide Resin (PAI). The first commercial PAI resin, Torlon, is produced by the solution condensation of trimellitic trichloride with methylenedianiline:



Torlon resin is an amber-to-gray colored amorphous polymer with an HDT of 274°C, flexural modulus of 4600 N/mm² (667 × 10³ psi), and good impact resistance. Although it contains amide linkages, it is dimensionally much more stable under various humidity conditions than standard crystalline nylons. As are aromatic polyamides and imides, Torlon is flame retardant and has low smoke emission. Creep under load is low. Electrical, chemical, hydrolytic, and radiation stability are excellent. Because of these properties, PAI can replace metal in gears, connectors, and other mechanical parts. It is also used in electrical applications where high temperature and chemical resistance are required.

Polysulfone Resins. Commercially important polysulfones (qv) are aromatic, ie, in the generalized formula for the repeating unit

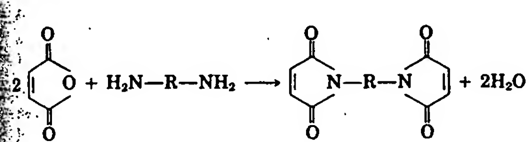


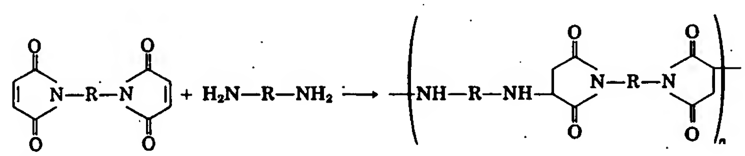
both R and R′ contain aromatic rings and ether linkages. The resins are made by batch processes employing Friedel-Crafts reactions or nucleophilic aromatic substitution.

Polyarylethersulfones are amber-to-yellow colored, transparent, amorphous resins. Because of high HDTs, resistance to thermooxidative conditions, and hydrolytic stability, they are suitable for appliances, electrical and electronic components, aircraft interior parts, and biological and medical devices requiring steam sterilization. Flammability and smoke generation are low. Udel resin has excellent microwave properties and is employed in dishware suitable for microwave ovens. These resins, however, are subject to attack by organic solvents. Melt flow is stiff, limiting the size and complexity of injection molded parts. The most serious problem with these resins is uv light instability. For outdoor use, a uv screen coating is recommended.

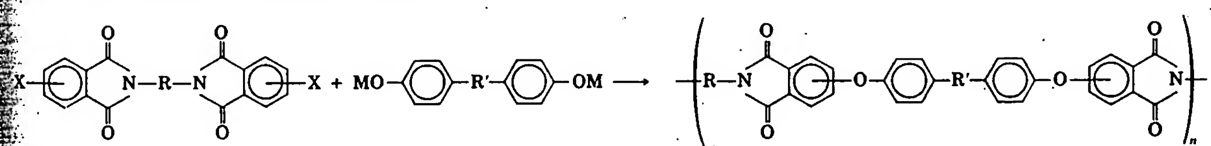
Polyimide Resins. Polyimide resins are used when heat and environmental resistance is required. Kapton resin and, more recently, Upilex resin are sold as films, partially polymerized resin coating solutions, and sinterable powders. These resins have extensive applications in the high performance insulation markets (traction motor, wire and cable) and flexible printed circuits. They are not melt reprocessible.

Upjohn's Polyimide 2080 resin, Rhone-Poulenc's Kerinide resin, Mitsubishi's BT resins, and Toshiba's Imidaloy resin are based on bismaleimide technology. Maleic anhydride reacts with a diamine to produce a diimide oligomer. Further polymerization by additional diamine and heat produces the resins:

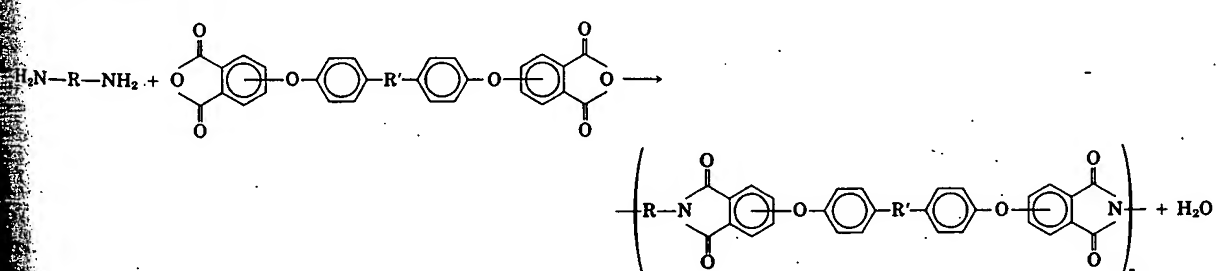




Polyetherimide Resins (PEI). Polyetherimide resins (PEI) are the newest generic engineering plastics. They are produced by an unusual nucleophilic substitution process:



where M = metal, or by a conventional condensation of diamines and dianhydrides:



Ultem PEI resins are amber colored and amorphous, with HDT between polyarylate resins and high temperature crystalline polymers, such as PEEK or PAI resins. Ultem resins exhibit high modulus and are stiff yet ductile. Light transmission is low. Despite the high use temperature, they are processible by injection molding, structural foam molding, or extrusion techniques at moderate pressures between 340 and

425°C. They are inherently flame retardant and generate little smoke; dimensional stabilities are excellent. Large flat parts such as circuit boards or hard disks for computers can be injection-molded to maintain critical dimension. Creep properties are excellent; for example, Ultem 1000 maintains its apparent flexural modulus for thousands of hours at a loading of 34 N/mm (4930 psi). Unlike PAI resins, annealing is not required. Chemical resistance is high for an amorphous resin. Ultem resins are unaffected by automotive organic chemicals and aromatic, chlorocarbon, and ester solvents; hydrolytic stability is excellent (see POLYIMIDES).

Ultem PEI resins are used in numerous engineering applications where a combination of heat, chemical, and flame resistance is needed. Typical uses include rigid memory disks, fuse bodies, gears, fans for computer and business equipment, sterilizable surgical appliances, hot combs, brushes, iron skirts, microwave-oven components, aircraft interior components, and high temperature switches, connectors, and circuit boards for industrial and military devices.

Poly(phenylene sulfide) Resins. Poly(phenylene sulfide) resins are manufactured from *p*-dichlorobenzene and sodium sulfide in a dipolar aprotic solvent. The polymer is crystalline with a melting point of 287°C. It is flame retardant and has excellent hydrolytic and chemical resistance. As do most crystalline polymers, the neat material exhibits high mold shrinkage and a tendency for molded parts to warp, which can be corrected by fillers and reinforcement. Although molded parts maintain their mechanical properties during prolonged heating, under some conditions the resin continues to polymerize. This reduces the thermoplastic character of the resin. Recycling should be carefully considered.

Poly(phenylene sulfide) resins are chiefly used for injection molding (see POLY(ARYLENE SULFIDES)S).

Polyester Resins. The general formula for engineering thermoplastic polyester resins is

$$\left(\overset{\displaystyle O}{\overset{\|}{C}} - R - \overset{\displaystyle O}{\overset{\|}{C}} - O - R' - O \right)_n$$

Most polyesters are based on phthalates. They are referred to as aromatic–aliphatic or aromatic according to the copolymerized diol.

Aromatic–Aliphatic Polyester Resins. Unlike most other classes of engineering plastics, which are made by only a few manufacturers, aromatic–aliphatic polyester resins are produced and compounded by several dozen firms.

Low molecular weight polyethylene terephthalate (PET) and poly(butylene terephthalate) (PBT) resins are made by melt processes. For higher molecular weight resins, melt processes followed by solid-state polymerizations are used. Although terephthalic acid can be directly esterified, the most common process involves transesterification of dimethyl terephthalate with ethylene glycol or 1,4-butanediol in the presence of trace amounts of metal ion catalysts.

The engineering applications of PET resins include injection-molded parts, blow-molded bottles, films, and extrusions. The PBT resins are mainly used for injection molding and related applications, although blow moldable grades are now appearing in the marketplace.

The properties given in Table 2 are for cream-color resins with good-to-excellent solvent resistance and good hydrolytic stability, but no clarity (see POLYESTERS, THERMOPLASTIC).

Aromatic Polyester Resins. Commercial aromatic polyester resins or polyarylates are a combination of bisphenol A with isophthalic acid or terephthalic acid. The resins are made commercially by solution polymerization

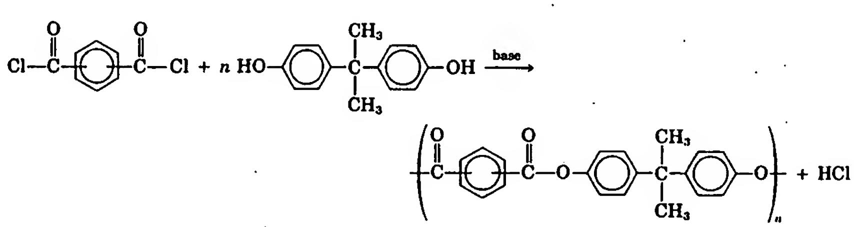


Table 2. Properties of Aromatic–Aliphatic Polyester Resins

Property	ASTM method	Valox 325[a]	Valox DR-51[b]	Rynite 530[c]
HDT at 1.82 N/mm² [d], °C	D 648	130	160	224
notched Izod at 20°C, 3.2-mm thickness, J/m[e]	D 256	50	55	90
flex modulus at 20°C, N/mm² [d]	D 790	2300	4530	6050
specific gravity	D 792	1.31	1.41	1.56
flammability rating, UL 94			V-O	HB

[a] Neat PBT resin.
[b] PBT resin, 15% glass-reinforced.
[c] PET resin, 30% glass-reinforced.
[d] To convert N/mm² to psi, multiply by 145.
[e] To convert J/m to ftlbf/in., divide by 53.38.